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VISUAL ACUITY UNDER RED VS. WHITE ILLUMINATION

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Bureau of Medicine and Surgery, Navy Department
Project MR005. 14-1001. 10

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SUMMARY PAGE

THE PROBLEM:

To compare the efficiency of central visual acuity under several levels of red and white light.

FINDINGS:

Acuity was found to be substantially the same under red and white light.

APPLICATION:

The findings of this study are pertinent to the problem of setting levels of red shipboard lighting which will permit adequate photopic acuity, yet interfere least with subsequent dark adaptation.

ADMINISTRATIVE INFORMATION

This investigation was undertaken as a part of the Bureau of Medicine and Surgery's Research Project MR005.14-1001.01 - Psychophysical Studies of Visual Factors in Submarine Operation. The present report is No. 10 on this subtask and was approved for publication on 18 January 1960.

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ABSTRACT

The central acuity of three observers was measured at three photopic levels (11.2, 1.2 and 0.34 ft-L) of red and white light using a multiple checker-board acuity tester. The red light was produced with Navy standard red filter.

Acuity was comparable under both colors. There was a small decrease under red light, but it was deemed to be of negligible importance.

VISUAL ACUITY UNDER RED AND WHITE ILLUMINATION

INTRODUCTION

It is a well established fact that the course of dark adaptation is more rapid after exposure to red than to white light. A given level of scotopic acuity will be reached approximately three minutes sooner after adaptation to low photopic levels of red light than after adaptation to an equal level of white light. And this saving in time increases as the level of the adapting light increases.¹ This phenomenon has been put to practical use aboard naval ships where it has often been important for lookouts to become dark adapted as quickly as possible after leaving interior illuminated areas.

Before it is possible to fix the level of red lighting, however, we must know the effect of the color of the light on acuity. It is conceivable, for example, that acuity diminishes under red light necessitating such an increase in the light level as to nullify the time saving in subsequent dark adaptation.

In an early study during the war, Ferree and Rand² reported that white light was better for acuity than red, but shortly afterwards Luckiesh and Taylor published work showing that at low light levels, red was significantly better for acuity.³ After the war, Martin and Pearse⁴ wrote that acuity was about the same under red or white at daylight levels of illumination, but that acuity was perhaps a little better with red at low levels, below 0.6 foot-Lamberts. But they said this was not certain; any difference between 0.3 and 6.0 ft-L was very small. Then Hartridge published a report concluding that visual acuity was approximately the same for all colors, having tested with white, red, green and blue.⁵

These investigators had tested ordinary acuity. It may be noted in passing that Baker then reported that when vernier acuity was tested, it was markedly better under red light from 0.0004 to 40 ft-L, and she ascribed this to chromatic aberration.⁶

Finally, Spragg and Rock⁷ have most recently reported that in a test of dial reading under different wavelengths, performance was poorest under red when the light level was 0.01 ft-L. When the level was raised to 0.1 ft-L, there was no clear difference. The bad effects, at any rate, were minor, the range of errors extending only from 20.1 to 23.5 per cent and the reading time extending from 2.10 to 2.25 seconds, differences of negligible practical importance.

The present investigation was undertaken specifically to attack the problem of shipboard lighting and has thus used red light produced with standard Navy red filters. The light levels were chosen to encompass the probable limits of shipboard lighting.

APPARATUS AND PROCEDURE

Acuity was tested with a multiple checkerboard acuity tester developed at this Laboratory and described in detail by Schwartz.⁸ This apparatus is one which presents a graded series of five checkerboard targets simultaneously. The sizes of the target "checker" squares were .050, .055, .060, .065, .070 inches and were originally chosen to be viewed from a distance of 20 feet at standard illumination of 12 ft-L. When the light level was decreased, therefore, it was necessary to place the observers at closer distances, which were determined in pre-experimental sessions with each 0.

For each one of three levels of red and white light there were eight readings of the five targets and five sessions for each condition all given in random order making an N of 40 for computing each frequency of seeing curve.

The differences in color and intensity of the lighting were obtained by using a set of goggles with various red and neutral density filters in the right eyepiece. The left eyepiece was occluded. The red filters, made from Navy standard red plastic with a cutoff at 590 mμ, were equated and paired to the nearest 0.1 density neutral filter by flicker photometry. The targets were set up against a white wall and when they were viewed through the appropriate goggle, a red or white brightness of 11.2, 1.2, or 0.34 ft-L was seen. For the two brighter conditions, 0 was adapted to the experimental light level for ten minutes. For the dimmest level, 0 was dark adapted for ten minutes and then exposed to the experimental light level for five minutes.

RESULTS AND DISCUSSION

The frequency of seeing curves obtained under red and white light at each of the three light levels are given for each 0 in Figs. 1-3. There is little difference between the red and white curves for the most part, but the thresholds under white are generally slightly lower than those obtained under red. It also appears that the standard deviations (indicating the precision of judgments) of the white curves are slightly smaller than those for the red curves in most cases. For observers AR and MC the differences are small,

and for the middle light level, MC's red standard deviation is smaller than the white. Most interesting however, are the curves for JK in Fig. 1. At the highest light level, the standard deviations of the red and white curves are similar. At the middle light level, while the white standard deviation has remained small, the red standard deviation has increased markedly. Then, at the lowest light level, the white standard deviation has also increased and both standard deviations are now similar once again, reminiscent of the Spragg and Rock results.

The thresholds read from the graphs in Figs. 1-3 have been converted into reciprocal visual angle and listed in Table I. These figures, perhaps more clearly than the graphs, show that the differences in acuity are too small to be of great practical importance.

These results indicate that little loss in central acuity will be suffered if the illumination is changed from white to red at the same intensity. This does not mean, of course, that the change in color can be achieved by simply masking a white bulb with a red cover; this procedure would reduce the light level by about 90 per cent and would markedly reduce acuity.

SUMMARY

The central acuity of three observers was tested under three levels (11.2, 1.2, and 0.34 ft-L) of red and white illumination. The results indicated that there was a small decrease in acuity under the red light, but it was deemed to be of negligible practical importance.

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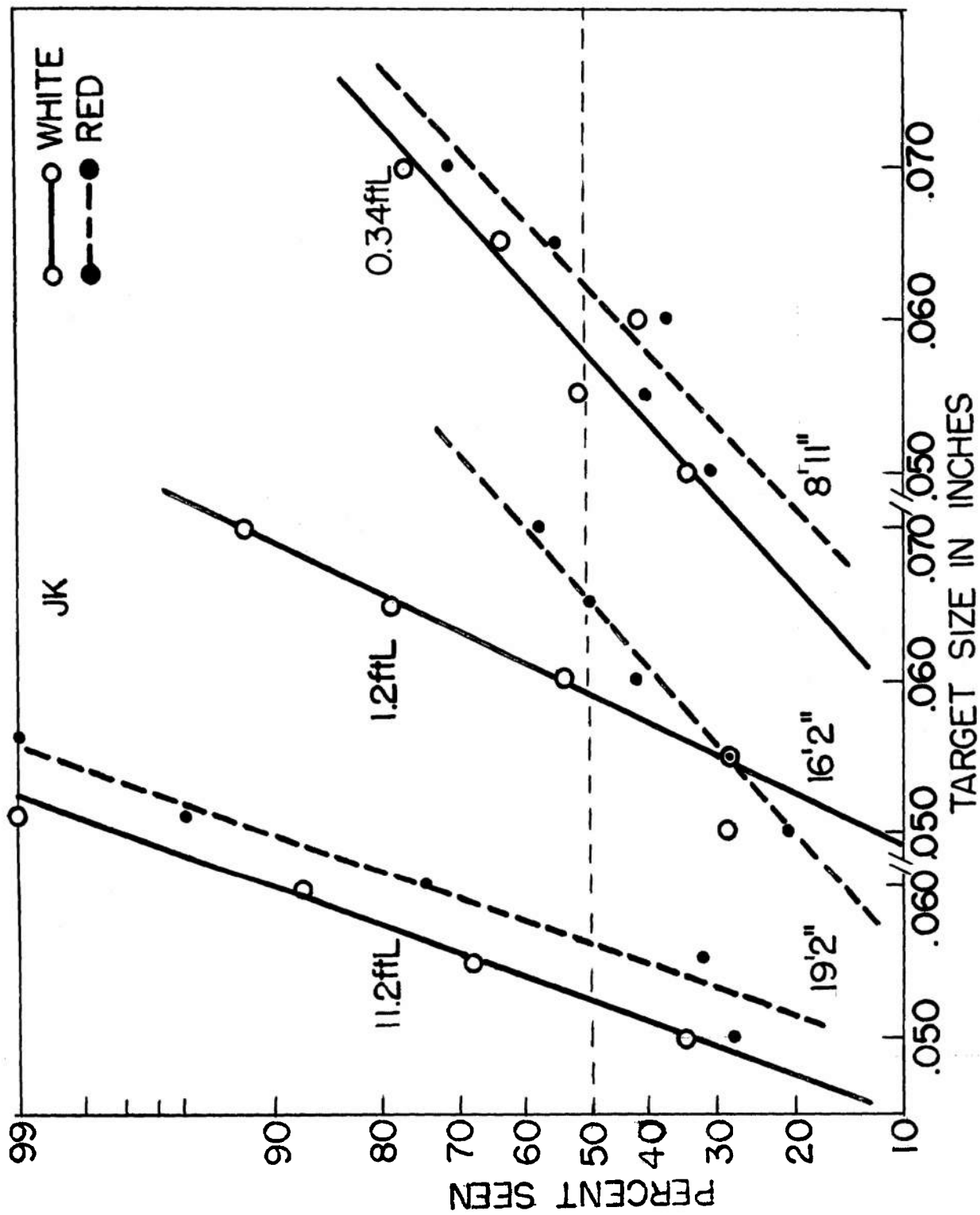


Fig. 1 The frequency of seeing curves for observer JK at the three levels of red and white illumination. The observer's distances from the target for a given condition are listed below the corresponding set of curves.

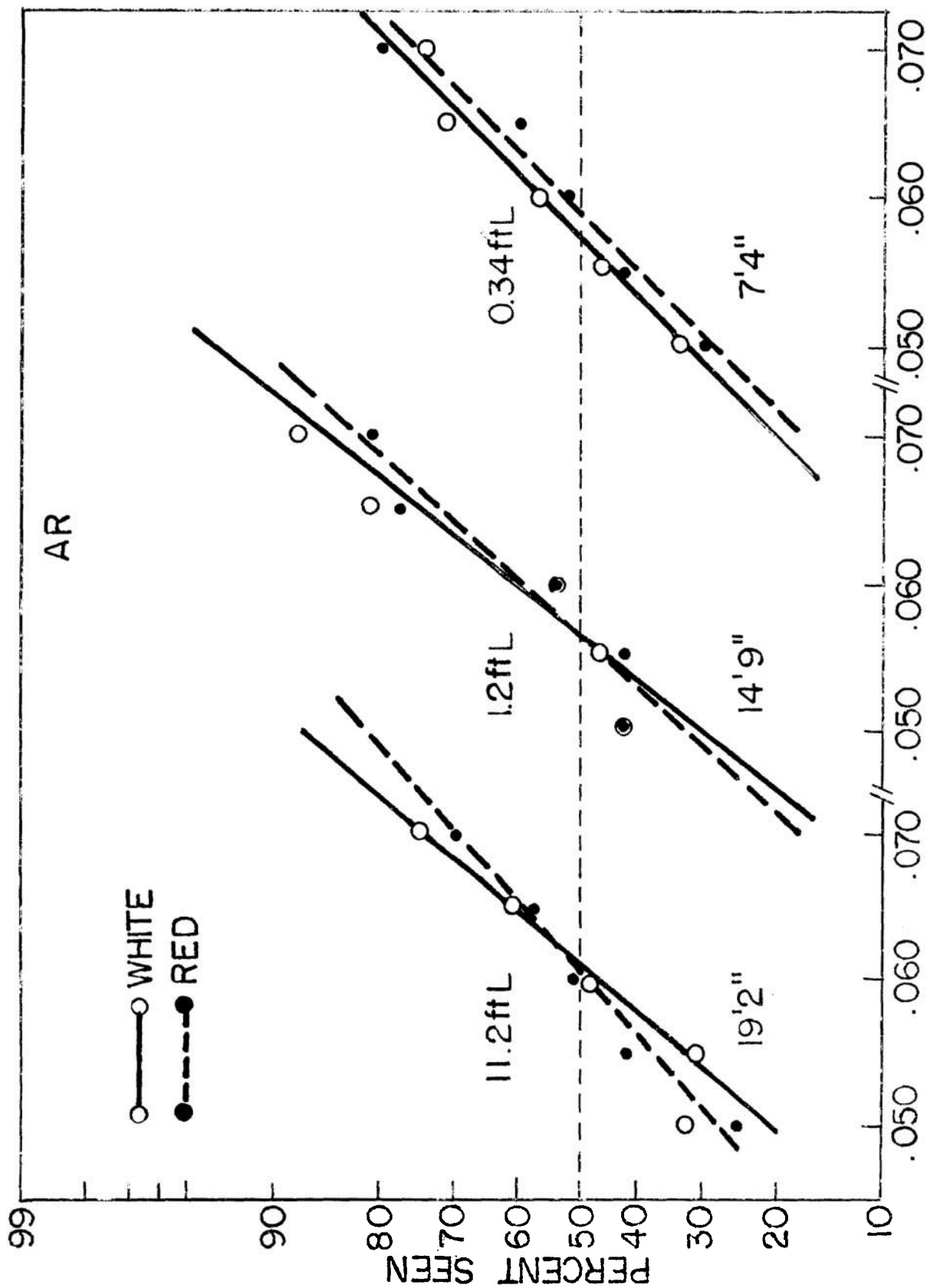


Fig.2 TARGET SIZE IN INCHES

The frequency of seeing curves for observer AR at the three levels of red and white illumination. The observer's distances from the target for a given condition are listed below the corresponding set of curves.

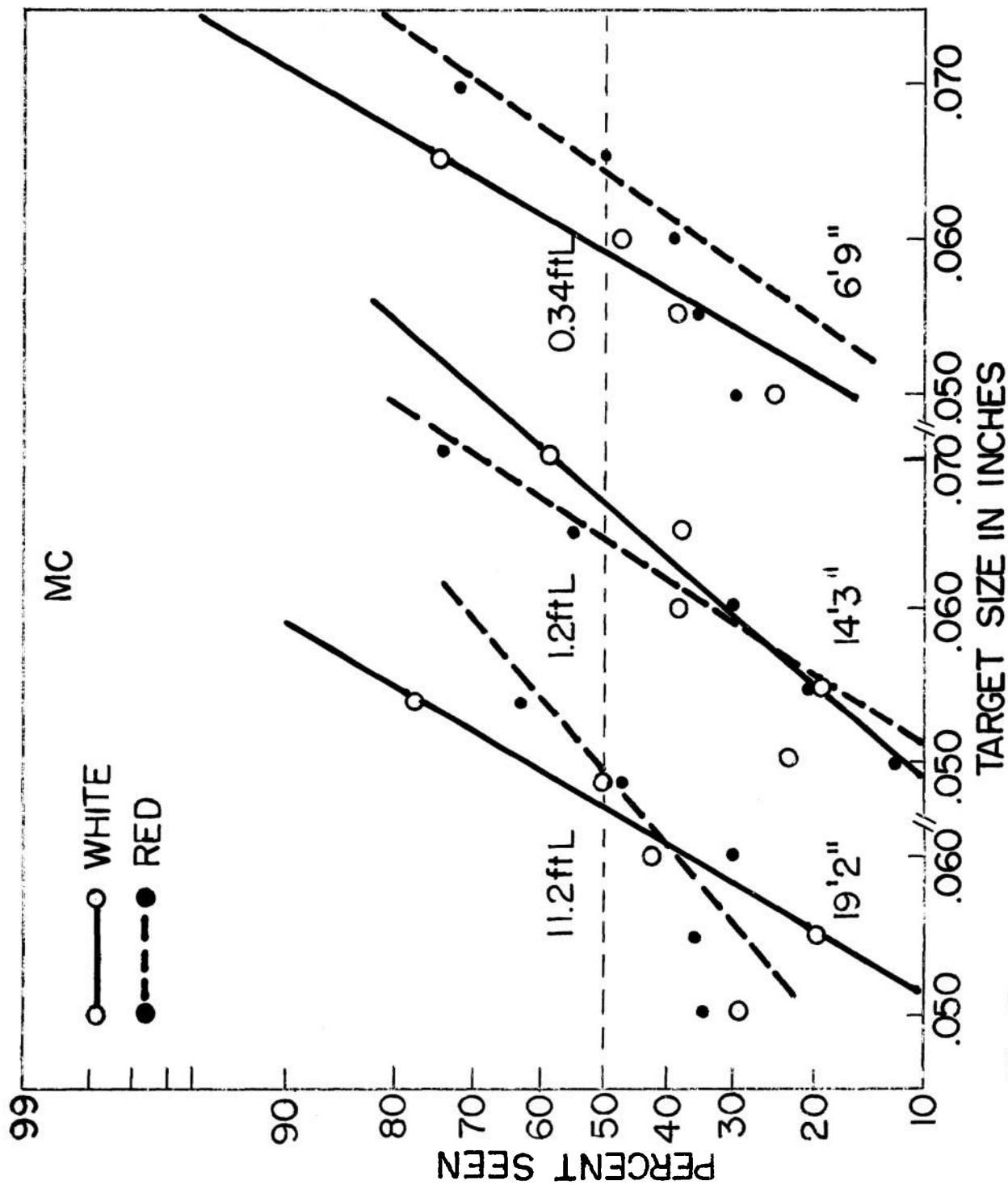


Fig. 3 The frequency of seeing curves for observer MC at the three levels of red and white illumination. The observer's distances from the target for a given condition are listed below the corresponding set of curves.

TABLE I. Visual Acuity of Three Os Under Three Levels of Red vs. White Brightness

Obs.	Adaptation	11.2 ft-L	1.2 ft-L	0.34 ft-L
JK	red	1.1737	0.8726	0.5020
	white	1.2920	0.9747	0.5359
AR	red	1.0963	0.9208	0.4409
	white	1.0965	0.9208	0.4492
MC	red	1.0288	0.7788	0.3704
	white	1.0616	0.7440	0.4805
Avg.	red	1.0996	0.8574	0.4378
	white	1.1500	0.8798	0.4645